EXPERIMENTAL POPULATION SUPPRESSION OF RICHARDSON'S GROUND SQUIRRELS (*Spermophilus richardsonii*) IN ALBERTA

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ABSTRACT: Richardson's Ground Squirrel is one of the most economically harmful rodents in east central Alberta. In an effort to develop an effective, safe, economical and practical method of long-term population control over large areas, experimental field testing was begun in 1970 to evaluate a variety of potential control techniques. Although tests with a machine bait applicator proved unsuccessful due to the unique soil structure, its potential in other areas of the province is discussed. Use of portable baiting stations is limited by the manufacturing and maintenance costs as well as the limited attractability of the stations. Attractability of the stations to ground squirrels was not increased with the use of reflector tops however it did have a repellent influence on raptors feeding in the area. Disposable baiting tubes appeared to have greater potential for large acreages and possible aerial application. Initial tests conducted with diethylstilbesterol and mestranol as chemosterilants are outlined. The potential of using techniques to regulate reproductive rate as opposed to increasing mortality rate is discussed. The potential of using amphetamines to reduce body weight and increase winter mortality during hibernation is also discussed.

Because of its exceptionally high densities at the present time the Richardson's Ground Squirrel (*Spermophilus richardsonii*) is currently one of the most economically harmful rodents in east central Alberta (Biggs 1970; Yaremko 1971). Through its burrowing and feeding habits this species has become a pest of significant concern to agriculturists of that area and, in response to requests for assistance, steps were initiated in 1969 to (a) determine the extent and severity of the problem and (b) determine the feasibility of conducting a range-land population suppression program in that area. Conventional methods of control are often criticized by naturalists, conservationists, because of the hazard to local populations of protected raptors. There is a lack of any significant influence on the rodent population from natural predators. Also high densities of ground squirrels in this area present the possible re-occurrence of an outbreak and spread of Alberta Rocky Mountain Spotted Fever and Sylvatic Plague (Brown et al. 1943).

Several researchers have indicated the shortcomings of using methods designed to effect population control by increasing mortality rate, as opposed to the advantages of controlling population densities by manipulating the reproductive potential of the population (Marsh and Howard 1969; Marsh and Howard 1970; Balser 1964b; Brooks and Bowerman 1969; Howard 1967a; 1967b; 1968; Pingale et al. 1967; Skinner 1968; Srivastava 1966; Weatherbee 1964). After reviewing all aspects of the problem, it seemed that the most practical and promising approach to satisfactory long-term, large-area control had already been theorized by Marsh and Howard (1970): to establish and evaluate an integrated program which would utilize toxicants applied as selectively as possible for an initial reduction of "hot spots" of ground squirrel concentrations, followed by larger scale aerial application of chemosterilants to keep the population at an economically tolerable level.

During the summers of 1970 and 1971 attempts have been made to (a) develop and evaluate economical and selective methods of applying toxicant baits (b) field test and evaluate the potential of diethylstilbesterol and mestranol as chemosterilants (c) determine the potential of artificially increasing mortality of females during hibernation by using fall application of amphetamines (d) monitor other members of the wildlife food chain for detrimental effects attributable to control measures.

METHODS

The experimental site used for all field tests was comprised of several 20 acre and 10 acre plots located near Youngstown, Alberta. One-third of the plots surveyed were used only as natural control areas. Buffer zones were located between study areas where the plots were grouped together.

Population Estimates

Population densities were established by visual counts on 1 acre observation plots and these counts were confirmed by burrow-digging counts (Dorrance 1970). These results were then verified by a mark-recapture method whereby a known number of animals were dyed and released. Following several days, a sample population was taken and an estimate of the total population was computed by the ratio of marked to unmarked individuals.

Underground Bait Application

On one study area, tests were conducted with a modified artificial burrow-making machine and untreated grain bait. The Elston-Howard machine was used in a manner similar to the method used for pocket gopher control, except that the torpedo was raised intermittently to leave a series of ground surface openings. Due to difficulties with cave-in, several modifications of the torpedo shape and bait metering mechanism were tried.

Portable Baiting Stations

Circular wooden self-feeder bait stations were constructed from half inch plywood with a diameter of 3 feet. All were covered with either a flat top wooden roof or a cone-shaped aluminum roof. The bait dispenser in the centre of the station was accessible to ground squirrels from all directions.

On two study areas food preference and palatibility tests were conducted to assist with the evaluation of portable baiting stations and to determine the actual distance to which ground squirrels could be attracted to these stations. From a central position at which the baiting stations were placed, four diameters - each radius being 100 feet larger than the previous - were marked off. Two types of baiting stations were field tested: (a) metal reflector-top type and (b) plain flat-topped type. As many ground squirrels as possible were trapped from each zone and were dyed with Nyanzol 2R in a pattern that would distinguish individuals inhabiting each zone.

Eleven aromatic oils as well as molasses and honey were tested on a wheat substrate to determine if the drawing power of the bait stations could be increased by using attractants.

Six bait substrates (wheat, oats, rolled oats, barley, rape seed, mustard seed) were tested for acceptability by placing selected substrates simultaneously in active bait stations. Conclusions were based on a preference by ground squirrels based on the relative amounts of bait substrate eaten.

Evaluation of Toxicants for Long-Term Control

During the first week of June, 1971 all ground squirrels in an 8 acre observation plot were artificially removed by shooting and poisoning, following determination of a population density of 28 ground squirrels per acre. Population counts were conducted again at the end of June to determine the rate of ingress from adjacent non-treated areas.

Disposable Baiting Tubes

Following an analysis of the economic feasibility of using portable baiting stations, tests were initiated with small disposable cylindrical baiting tubes. One and two-foot-length cardboard tubes of 3,4,5 and 6 inch diameters were tested to determine if ground squirrels had a preference for a specific sized tube. Results obtained were by visual observation following spreading of sand at both openings of the tubes to confirm visits.

During early August tubes with diameters of 3 and 4 inches were distributed by hand at a density of 5 tubes per acre on a test area. The tubes contained a spoonful of 2% strychnine treated wheat to determine the effectiveness of toxicants applied with this technique as a method of population control. Pre and post-test population densities were determined by the mark-recapture method in order to determine the degree of control.

Chemosterilants

Under laboratory conditions 8 males and 8 females were injected with 1cc each of 0.05 mgs. per cc diethylstilbesterol - mineral oil solution in an attempt to confirm the

effectiveness of this dose rate. Sham controls were injected with an intra-muscular injection of 1cc light mineral oil. The animals were maintained for 30 days and then the gonads were extracted, and weighed along with body weight.

Also, in early August, 34 animals were live-trapped, injected with one of three concentrations of 1cc solution of diethylstilbesterol (0.001, 0.05 and 5.0 mgs. per cc), toe-clipped, color-marked with 6% hydrogen peroxide soap and black hair dye. Fifteen sham control animals were injected with 1cc light mineral oil. All were released on the same study area that they were collected from. The purpose of this experiment was to determine if a fall administration of diethylstilbesterol would possibly influence the fertility of a population during breeding the following spring.

Mestranol

Trapping of lactating females for an intra-muscular injection began May 26, and continued to June 2, 1971. Thirty-five animals (26 females, 9 males) were injected with 1cc dilution of 2.5 mgs. per cc mestranol (17-ethynyl-3-methoxyestra-1,3,5(10)-trien-17-ol), toe-clipped, dyed, and released. Sham controls were similarly marked and injected with 1cc of mineral oil. During the third week of June some of the injected animals were trapped and the effect of mestranol on uterine and gonad weights was determined. The effect of mestranol on gonad weights from the young of injected females was also determined in the laboratory following the capture of 8 such juveniles (3 females, 5 males in late July).

At the beginning of July, 1971 a laboratory colony of 24 animals from the vicinity of experimental plots was established and housed in groups of 3 per cage. Each cage of animals was offered a free choice between containers with treated and untreated diets (treated with mestranol) for one week, and their responses were compared to a group of controlled squirrels offered a free choice between two containers of non-treated standard ration. The concentrations of mestranol offered were 0.05 percent, 0.005% and 0.0005%. Four females and 2 males were exposed to each of the concentrations of mestranol-treated wheat. The controlled group consisted of 3 females and 3 males. Mestranol was dissolved in sunflower oil to facilitate its mixing with wheat. Food consumption from each feeder was determined by weighing the feeders at 24 hour intervals. After each weighing, the feeders in each cage were reversed in position to help nullify any position preference in food consumption. Water was provided ad libitum. All feeders were emptied and refilled with freshly prepared rations on the third day of the experiment to preclude possible changes in palatability. At the end of one week test period, the gonads were excised and the weights were taken.

Two juvenile ground squirrels were captured on May 27, 1971 (the first young to emerge) were administered mestranol-treated milk (0.05% by weight) on June 3. The effect on reproductive organs was determined by weight after their death on June 6 from an apparent overdose.

Dextroamphetamine Sulphate

In order to determine a working dosage, a number of squirrels were trapped and given the drug at various doses (10 mgs. 5 mgs. 3 mgs. 2 mgs.) and optimum dosage was gauged by a desired increase in observed motor activity in a semi-confined area. They were housed in a large abandoned building at the experimental site and were provided with sufficient food and water. Experimentation was also done with various application methods: by intra-muscular injection, force feeding, and by tablet implantation at the base of the tail.

On a selected study area 32 ground squirrels were injected with the drug (3 mgs. per ml.) just prior going into hibernation. Ten received a single 1 ml. injection; 12 received 2, 1 ml. injections; and 10 received 3, 1 ml. injections and were released from the same location at which they were captured.

RESUME OF RESULTS

Experimentation with three modifications of the torpedo on the artificial burrow-building machine in varying soil conditions failed to produce a functional artificial burrow. However, ground squirrels were observed to show considerable exploratory behavior with respect to the openings created in the soil surface.

Attractability of the circular-baiting stations was found to be limited, at this particular time of year, to a maximum of 300 feet with no significant effect on attractability attributable to the reflecting tops:

Attractability of Circular-baiting Stations:

Experimental Zones:	N	% Marked Animals Attracted to Reflector Tops:	% Marked Animals Attracted to Non-Reflector Tops:
Zone 1(100 feet)	9	77.7	77.0
Zone 2(100 feet-200 feet)	14	21.5	35.7
Zone 3(200 feet-300 feet)	23	21.5	14.3
Zone 4(300 feet-400 feet)	40	Nil	Nil

One exception was one particular individual who consistently visited one baiting station from a distance of more than 500 feet. Cost-benefit analysis regarding the practicality of using portable bait boxes indicated possible economic feasibility on acreages up to 100 acres but not more.

Acceptance of the bait substrates in order of preference (during July) were:

1) wheat or coarse rolled oats (apparently preferred equally)

2) oats

3) barley

4) mustard seed

5) rape seed

Several materials were tested to enhance the attractability of the bait substrates with limited success: treatment of bait substrates with green dye caused no significant increase in bait acceptability although it was found that almond and maple attracted the ground squirrels to a slight extent; aniseed, dill, and cassia oil acted as deterrents. Cloves, lavender, citronella, lemon, wild strawberry, peppermint, molasses, and honey acted as neither attractants nor deterrents.

Evaluation of Toxicants for Long-Term Control

The population density in the area, before control measures were applied, was determined by the mark-recapture method at 28.0 squirrels per acre. Twenty days following the removal of all animals from the area, population density on the site was 29.2 ground squirrels per acre - mostly juveniles.

Disposable Baiting Tubes

Observation studies on a designated area where various sizes and lengths of baiting tubes were distributed indicated that ground squirrels preferred the smaller diameter tubes. The length of the tube did not have an observed affect on preference as long as both ends of the tube were open. All ground squirrels within a 25 yard radius were observed to explore and enter the tube.

Baiting Tube Size Preference by Ground Squirrels:

Diameter of Baiting Tubes:	Number of Squirrels Which Entered
3 inches	17
4 inches	14
5 inches	6
6 inches	4

During August tests for efficiency of the baiting tubes (applied at 5 tubes/acre with toxicant) a 55% population decline was observed on a 10-acre test plot. Prior to application of the tubes the population was estimated to be 9 ground squirrels per acre. Two weeks following application of the tubes on the test area population density was calculated at 4.1 per acre, compared to the control area population which remained unchanged during the same interval.

Chemosterilants

The effect of diethylstilbesterol intra-muscular injections on gonad weight and histology indicated that a dose of 0.05 milligrams was sufficient to cause apparent atrophy in gonadal cellular morphology. This may or may not represent a dose rate which would inhibit gamatogenesis.

Fall injections of diethylstilbesterol into three ground squirrels, which were recovered in the spring, apparently had no effect on reproductive potential. NOTE: Only three of the 34 animals treated in the fall of 1970 were recovered in the spring of 1971.

Treatment with Mestranol

Figure 1 indicates that the percent weights of reproductive organs is reduced in the young of females treated with mestranol.

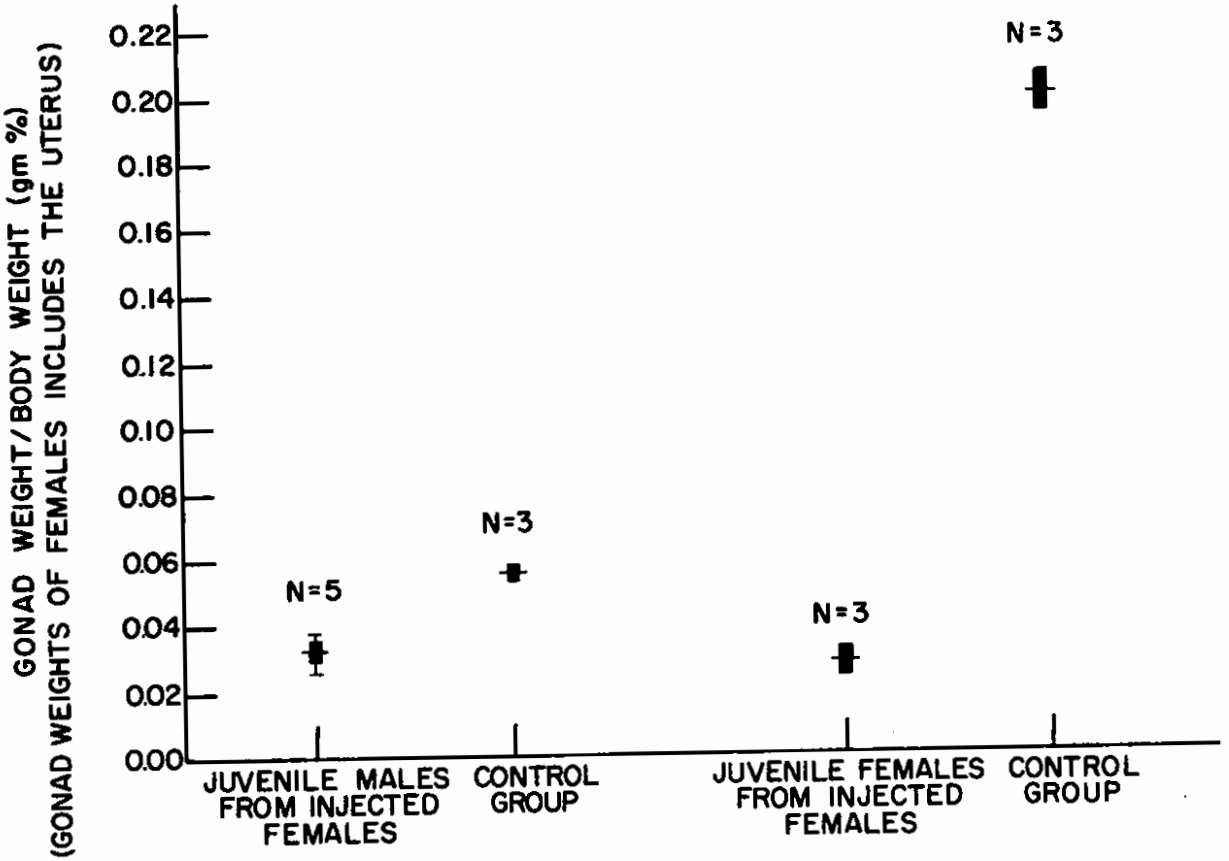

Figure 1. Effects of mestranol on gonad weights of juveniles which received the steroid via their mother's milk. The vertical line represents the range, horizontal lines the mean values, and the solid columns represent the computed plus or minus two standard errors. N equals the sample size.

Further bait acceptability tests with mestranol treated diet rations under laboratory conditions revealed that bait mixtures with concentrations of greater than 0.05% mestranol may reduce palatability significantly.

DISCUSSION AND CONCLUSIONS

The severity of the damage to range in the Special Areas of east central Alberta is verified by our finding of 25-30 ground squirrels per acre (average - 1970) with 350-400 (average) burrow openings per acre. In that ground squirrels are currently consuming approximately 90 pounds of forage per acre per month, efforts to find a practical method of population control have intensified.

Although results of tests in past years conducted on Columbian Ground Squirrels (Archibald 1967) indicated that ground squirrels tended to be attracted to shiny objects, we did not find the use of reflector tops on the bait boxes to increase attractability of the baiting stations significantly. It was observed however that the reflector tops did seem to have a repellent effect on birds of prey looking for dead or dying ground squirrels. In view of the concern for raptorial species in the area it was considered that the reflector top would remain a desirable and worthwhile feature.

Despite our findings from stomach and food habit analysis in 1970, that ground squirrels in the area were consuming large amounts of green forage, food preference tests indicated that wheat or coarse rolled oats was probably the best bait substrate to be used. Color did not seem to increase the acceptability of the bait although it was theorized that green may have an influence in that we observed that ground squirrels tended to be attracted to green forage especially early in the spring. Tests with a number of potential attractants have led us to believe that they probably wouldn't increase attractability of baits sufficiently to warrant the cost of including them in a final bait preparation. It was interesting to note that one of the test materials, ordinarily used as an attractant in commercially prepared strychnine gopher poison, actually acted as a deterrent in our tests. A similar observation was recorded earlier when Barnett and Spencer (1953) tested the attractiveness of aniseed oil odor on wild rats.

Despite the fact that studies on other non-target wildlife species in the vicinity were abbreviated due to insufficient staff, residue analysis on four species of predators and three species of seed-eating birds did not indicate that a secondary poisoning hazard existed when 2% strychnine was used as a toxicant. Nevertheless non-target influences should always be closely monitored, (especially when toxicants are used) in that approximately 75% of the ground squirrels consuming strychnine bait die outside their burrows (Biggs 1970).

Our tests, which revealed a high rate of ingress following direct control measures within a short period of time, tend to confirm similar results by Dorrance (1970). These results indicate the shortcomings of using techniques which attempt to facilitate control by effecting mortality rate only. If large areas were treated similarly it is expected the same phenomenon would occur, only over a slightly longer period of time. We are now of the opinion that long-term practical population suppression involves chemical regulation of the reproductive potential of the ground squirrel population.

Controlled fertility provides advantages lacking in conventional methods of population control which emphasized their effects on mortality rate. When animal numbers are regulated through increased mortality, compensating factors such as increased productivity, increased juvenile survival and ingress of animals from adjacent areas usually results. Reduced fertility among adults eliminates increased productivity, and adult-juvenile competition prevents increased survival of juveniles. The control of birthrates prevents ingress of animals, as adults remain in the population and maintain territorial rights.

The lack of opportunity we have had to conduct extensive tests with chemosterilants on our ground squirrel population is probably responsible for the lack of any conclusive information that we have regarding the feasibility of large-acreage application. A number of researchers already mentioned have discussed favorably the potential of using chemosterilants to control rodents, however, most of their conclusions are based on experimental work with rats. It is anticipated that application of chemosterilants for ground squirrel population control could be much more practical and effective in that these rodents breed only once a year.

Also, the large flat, open areas of ground squirrel habitat tend to facilitate easy application by air.

There is need for much more information and evaluation concerning the best chemosterilant to be used. On limited numbers of animals we have indications by reduced gonadal weight and histological changes that a 0.05 mg. dose of diethylstilbesterol may be sufficient to inhibit gamatogenesis in the adult cohort provided it is applied at the proper time of year (just prior to breeding). We had not had ample time to determine whether or not the effect of this chemosterilant will provide a practical and efficient means of reducing productivity in the population. It seems to be obvious that a fall application of diethylstilbesterol, regardless of the dosage, will not be effective in inhibiting reproductive potential the following spring. It may be significant however that only three of 34 animals treated in the fall were recovered the following spring. The fall treatment with diethylstilbesterol may have accidentally increased mortality rate during winter by interfering, in some unknown way, with physiological homeostasis during hibernation.

The assumptions we have drawn regarding probable effective dose rates are approximate only in that we have not had an opportunity to test these dose rates under field conditions for influence on actual reproductive potential. Although a reduced gonad weight resulting from a specific dose level of chemosterilant injected does not necessarily mean reduced reproductive potential, it is probably a good "indicator" that reproductive capacity will be interfered with and a drastic effect on gonad weight could very likely indicate loss of reproductive potential.

Our trials with mestranol as a practical and efficient chemosterilant are likewise inconclusive at this time due to lack of extensive field testing. There are indications however that the material will likely be more effective as a chemosterilant on ground squirrel populations than on rats (Marsh and Howard 1969), in that ground squirrels breed and reproduce once a year compared to rats which can breed and reproduce many times during the year. We do have indications however from our laboratory tests that there are problems with bait acceptability when mestranol is used in concentrations of greater than 0.05%.

There is beginning to appear in the literature sufficient information to indicate that mortality during hibernation is regulated or influenced somewhat by the ability of the animal to accumulate body and brown fat prior to hibernation. A fall treatment with amphetamine injections may reduce fat reserves sufficiently to cause an increase in winter mortality during hibernation. Recovery of the treated animals in the spring of 1972 may give us some indication of the practicality and efficiency of this method of control. It is interesting to note that animals treated with this substance underwent a slight, but observable, "personality change" and exhibited a lack of inhibition towards human activity and other activity which would normally frighten them. It is possible and highly probable that treatment with this drug would also serve to enhance mortality and efficiency of natural predation by making the ground squirrel population (treated) more vulnerable to predation by their lack of fear elicited as a result of treatment with this drug. Recent restrictions placed on the sale and distribution of this drug by our Canadian government may severely curtail further tests and the likelihood of development of this technique as a method of ground squirrel control.

We place a great emphasis and anticipation on the role of chemosterilants as a practical and efficient large-area and long-term method of population control. The emphasis on reduced natality from increased mortality as a method of regulating populations is certainly sound from a biological point of view. It is also a much more palatable approach to population control in the eyes of naturalists and conservationist groups. However, we recognize that from an applicator's point of view it is necessary to exercise just as much caution in applying chemosterilants as one would use using lethal chemicals. This is essential because any substance which inhibits cell division and suppresses actively proliferating tissue also possesses mutagenic and carcinogenic properties. In other words, the application and development of chemosterilants as a method of control will not make the applicator's job in the final analysis any easier. He still will be concerned with specificity, and selective time of application in order to gain maximum efficiency, practicality and economy from this particular method. It is hoped that our future efforts to field test chemosterilants on Richardson's ground squirrels on a larger scale, in addition to evaluating the effect of chemosterilization of their behaviour and population dynamics (Goulet 1971) will determine the long-term practicality and effectiveness of this apparently biologically sound approach.

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